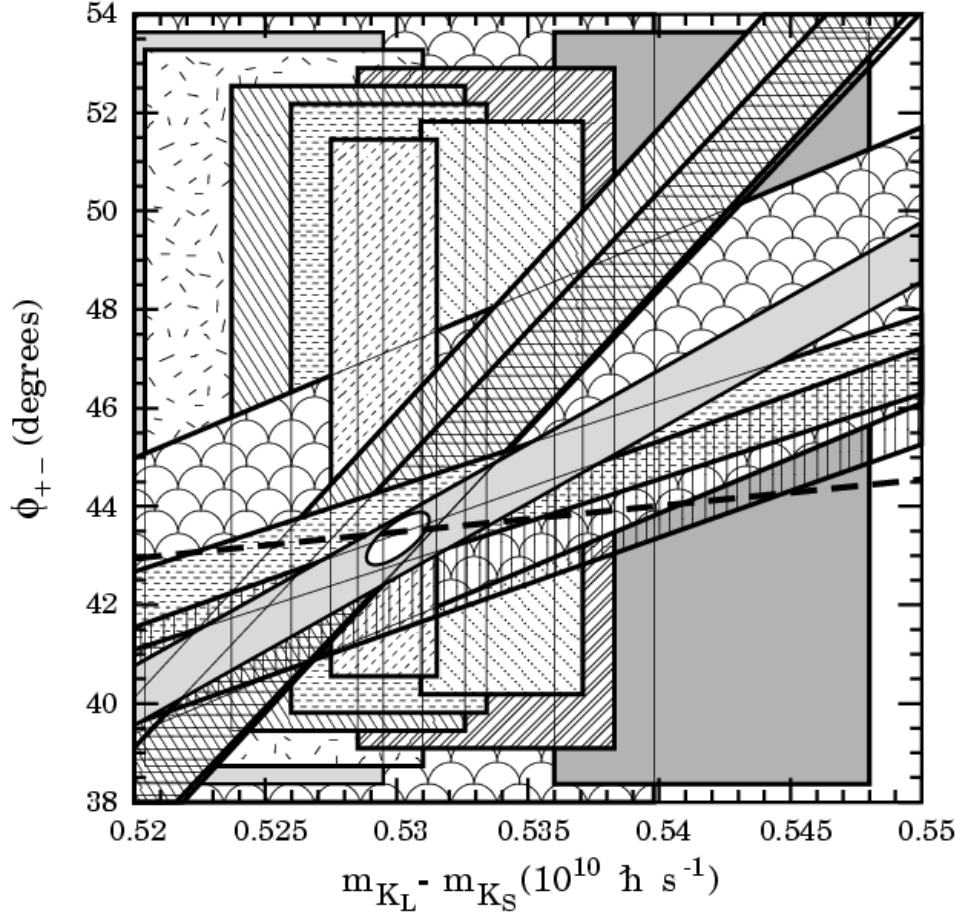# Kaons,
Heavy Bosons, Technicolor, Compositeness

Tom Trippe

PDG Advisory Committee Meeting

December 17, 2000

Kaons

- G. Conforto (encoder), T. Trippe (overseer)
- 39 papers added between 1998 and 2000 editions
  - Rare K decays, esp. $K^+ \to \pi\nu\nu$, πee, $K_L \to \mu\mu$, $e\mu$ (BNL) $K_L \to \pi\nu\nu$ limit, $\pi\gamma\gamma$ (FNAL), T violation, CPT Invariance in K^0-K^0 mixing (CERN)
  - CP violation params. $Im(\eta_{000})$,
- New Review
  - CPT Invariance Tests in Neutral Kaon Decay, P. Bloch.
- Significantly Revised Reviews
  - Rare Kaon Decays, L. Littenberg and G. Valencia
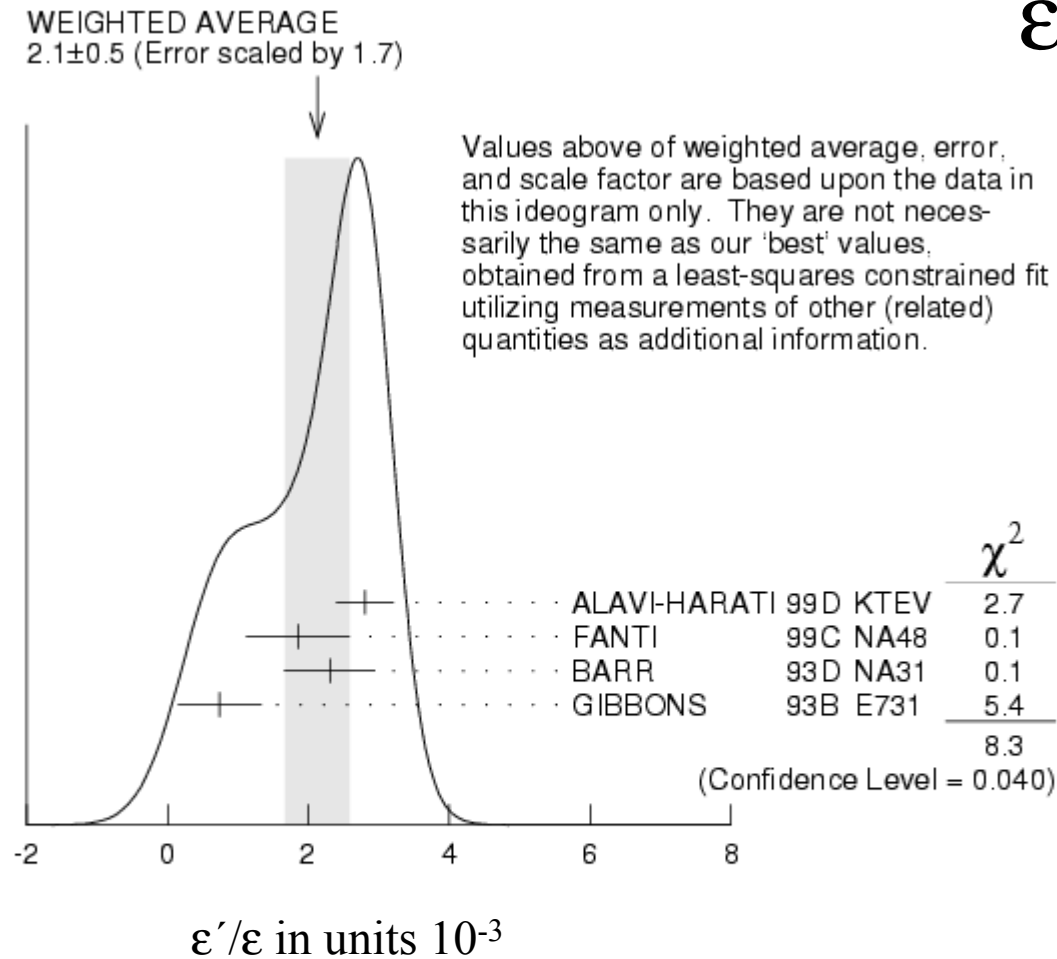 - Fits for K_L CP-Violation Parameters, T. G. Trippe

Legend:
- ANGELOPOULOS 98D
- GEWENIGER 74C
- SCHWINGENHEUER 95
- GJESDAL 74
- CULLEN 70
- GIBBONS 93C
- APOSTOLAKIS 99C
- GIBBONS 93
- GEWENIGER 74B
- CAROSI 90
- CARITHERS 75
- $- -$ ϕ (superweak)
- Fit result

Figure 1: ϕ_{+-} vs Δm. Δm measurements appear as vertical bands spanning $\Delta m \pm 1\sigma$, some of which are cut near the top to aid the eye. The ϕ_{+-} measurements appear as diagonal bands spanning $\phi_{+-} \pm \sigma_\phi$. The dashed line shows ϕ(superweak). The ellipse shows the 1σ contour of the fit result. See Table 1 for data references.
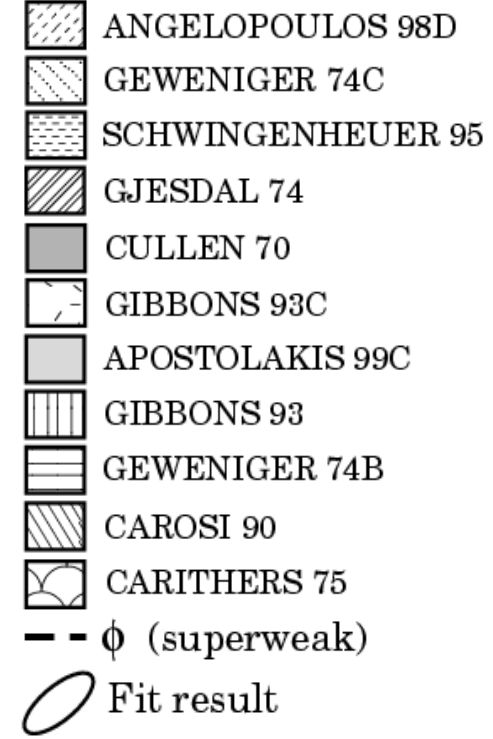
Table 2: Results of the fit for ϕ_{+-}, ϕ_{00}, $\phi_{00} - \phi_{+-}$, Δm, and τ_S. The fit has $\chi^2 = 16.0$ for 20 degrees of freedom (24 measurements -5 parameters $+1$ constraint).

Quantity	Fit Result
ϕ_{+-}	$43.3 \pm 0.5°$
Δm	$(0.5300 \pm 0.0012) \times 10^{10} \hbar \, s^{-1}$
τ_S	$(0.8935 \pm 0.0008) \times 10^{-10} s$
ϕ_{00}	$43.2 \pm 1.0°$
$\Delta \phi$	$-0.1 \pm 0.8°$

ε'/ε in K_L decay

WEIGHTED AVERAGE
2.1±0.5 (Error scaled by 1.7)

Values above of weighted average, error, and scale factor are based upon the data in this ideogram only. They are not necessarily the same as our 'best' values, obtained from a least-squares constrained fit utilizing measurements of other (related) quantities as additional information.

				χ^2
ALAVI-HARATI	99D	KTEV	2.7
FANTI	99C	NA48	0.1
BARR	93D	NA31	0.1
GIBBONS	93B	E731	5.4
			8.3

(Confidence Level = 0.040)

-2   0   2   4   6   8

ε'/ε in units 10^{-3}

$$\epsilon'/\epsilon \approx \mathrm{Re}(\epsilon'/\epsilon) = (1 - |\eta_{00}/\eta_{+-}|)/3$$
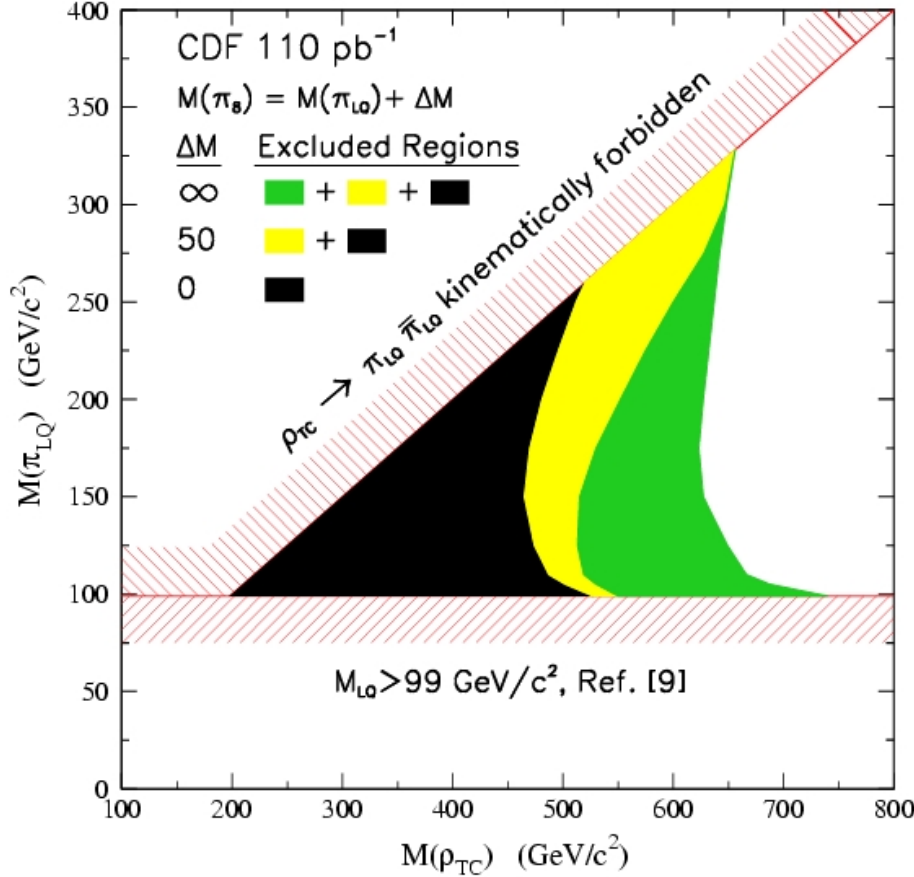
Future

- New ε'/ε coming soon from KTeV and NA48
- New rare K decays from BNL, KTeV and NA48
  - flavor changing neutral currents, lepton number violation
- K decay results starting to come out of HYPER-CP
- Ke4 decays from BNL E865→Chiral Perturbation Theory parameters
- Further work on CP violation fits
  - Separate $\Delta M(K_L\text{-}K_S)$ measurements which assume CPT. Meet in March at U. Chicago to sort this out.

Heavy Bosons and Technicolor

- M. Tanabashi (encoder), C. Kolda (overseer), T. Trippe (coordinator).

- Updated W′, Z′ data (28 new papers) and Reviews

- Eliminated many old and outdated theory limits

- Problems in Heavy Bosons

  - Z′ mixing angle limits appear only in footnotes of mass section. Perhaps create mixing angle data sections.

  - Kinetic mixing between Z′ and hypercharge quantum number may be important, but difficult to encode

Heavy Bosons and Technicolor (cont.)

- New Technicolor section
  - New review: Dynamical Electroweak Symmetry Breaking, by R. S. Chivukula and J. Womersley
  - Review includes published and preliminary data
  - New data listings (4 published papers)

CDF 110 pb^{-1}

$M(\pi_8) = M(\pi_{LQ}) + \Delta M$

ΔM	Excluded Regions
∞	green + yellow + black
50	yellow + black
0	black

$\rho_{TC} \rightarrow \pi_{LQ}\bar{\pi}_{LQ}$ kinematically forbidden

$M_{LQ} > 99$ GeV/c^2, Ref. [9]

M(π_{LQ}) (GeV/c^2)

M(ρ_{TC}) (GeV/c^2)

Figure 6: 95% CL exclusion region [24] in the technirho-technipion mass plane for pair produced technipions, with leptoquark couplings, decaying to τq.

Table 1: Summary of the mass limits. Symbols are defined in the text.

Process	Excluded mass range	Decay channels	Ref.
$p\bar{p} \rightarrow \rho_T \rightarrow W\pi_T$	$170 < m_{\rho_T} < 190$ GeV for $m_{\pi_T} \approx m_{\rho_T}/2$	$\rho_T \rightarrow W\pi_T$ $\pi_T^0 \rightarrow b\bar{b}$ $\pi_T^{\pm} \rightarrow b\bar{c}$	[13]*
$p\bar{p} \rightarrow \omega_T \rightarrow \gamma\pi_T$	$140 < m_{\omega_T} < 290$ GeV for $m_{\pi_T} \approx m_{\omega_T}/3$ and $M_T = 100$ GeV	$\omega_T \rightarrow \gamma\pi_T$ $\pi_T^0 \rightarrow b\bar{b}$ $\pi_T^{\pm} \rightarrow b\bar{c}$	[15]
$p\bar{p} \rightarrow \omega_T/\rho_T$	$m_{\omega_T} = m_{\rho_T} < 250$ GeV for $m_{\omega_T} < m_{\pi_T} + m_W$ or $M_T > 300$ GeV	$\omega_T/\rho_T \rightarrow \ell^+\ell^-$	[16]*
$e^+e^- \rightarrow \omega_T/\rho_T$	$m_{\omega_T} = m_{\rho_T} < 190$ GeV	$\rho_T \rightarrow WW,$ $W\pi_T,\ \pi_T\pi_T$ $\omega_T \rightarrow \gamma\pi_T$ $\pi_T^0 \rightarrow b\bar{b}$ $\pi_T^{\pm} \rightarrow b\bar{c}$	[18]*
$p\bar{p} \rightarrow \rho_{T8}$	$260 < m_{\rho_{T8}} < 480$ GeV	$\rho_{T8} \rightarrow q\bar{q},\ gg$	[22]
$p\bar{p} \rightarrow \rho_{T8}$	$m_{\rho_{T8}} < 465$ GeV	$\rho_{T8} \rightarrow \pi_{LQ}\pi_{LQ}$ $\pi_{LQ} \rightarrow \tau q$	[24]
$p\bar{p} \rightarrow g_t$	$0.3 < m_{g_t} < 0.6$ TeV for $0.3m_{g_t} < \Gamma < 0.7m_{g_t}$	$g_t \rightarrow b\bar{b}$	[28]
$p\bar{p} \rightarrow Z'$	$m_{Z'} < 650$ GeV for $\Gamma = 0.012 m_{Z'}$	$Z' \rightarrow t\bar{t}$	[29]*

*Preliminary, not yet published.

Technicolor problems

- FCNC constraints of Extended Technicolor are dependent on assumptions and difficult to encode.

- No "standard" or "benchmark" TC model so difficult to encode. Review and extensive footnote to the data are required.

- Techni-hadrons can be regarded as strongly interacting versions of Z', axigluon, leptoquarks, could encode there, but needs extensive footnotes.

- Models combining extra dimensions and topcolor are too theoretical at present to encode.

Compositeness

- M. Tanabashi (encoder), C. Carone (overseer), T. Trippe (coordinator).

- Updated Listings for 20 new papers

- Effective Lagrangian method well-defined at tree level, so gives "benchmark" test for experiments

- Problems
  - Not well-defined at loop level. Don't encode limits from one-loop effects
  - SUSY composite models too theoretical and not for RPP encoding at present
  - Perhaps encode $1/\Lambda^2$ instead of Λ^+ and Λ^- since it is more directly constrained by experiment.